A DEVELOPMENTAL BROADCAST FREQUENCY MODULATION STATION

12

A THESIS

Submitted in partial fulfillment
of the requirements for the Degree of

ELECTRICAL ENGINEER

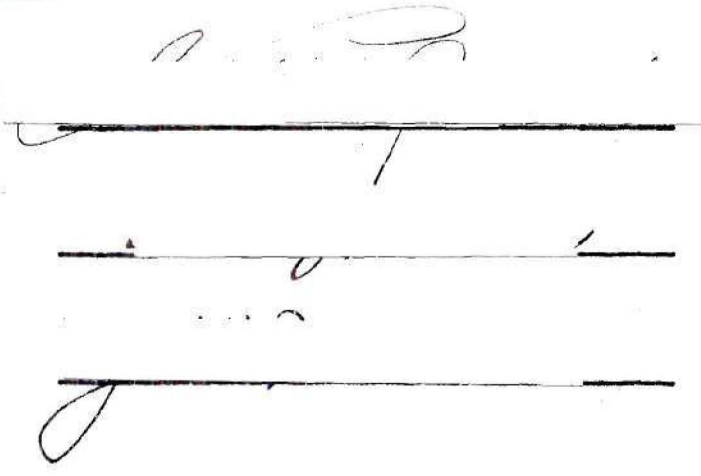
by

Martial A. Honnell

Georgia School of Technology
Atlanta, Georgia
1945

A DEVELOPMENTAL BROADCAST FREQUENCY MODULATION STATION

Approved:



Date Approved by Chairman Oct. 9, 1945

ACKNOWLEDGMENTS

To Col. Blake R. Van Leer, President of the Georgia School of Technology, and to the Regents of the University System of Georgia, I wish to express my gratitude for their generous allocation of funds which made this project possible.

I wish to express my sincere appreciation to Mr. Ben Akerman, Chief Engineer of Radio Station WGST, for his suggestion of the FM project and for his assistance in procuring the transmitter and associated equipment.

I wish to thank Dr. Gerald A. Rosselot, Director of the State Engineering Experiment Station, for his continued encouragement and for his many valuable suggestions in the prosecution of the FM problem.

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A DEVELOPMENTAL BROADCAST FREQUENCY MODULATION STATION

INTRODUCTION

At the November, 1935, meeting of the Institute of Radio Engineers in New York City, Professor Edwin H. Armstrong of Columbia University delivered a paper describing his "method of reducing disturbances in radio signaling by a system of Frequency Modulation". In 1938 there was one experimental FM station operating in the United States. As late as 1941, there were only 11 experimental FM Stations in operation. In 1941, the Federal Communications Commission authorized commercial sponsorship of programs on FM stations with the result that 53 FM broadcasting stations were in operation in 1943.

World War II stopped the expansion of all civilian radio services. Therefore, as late as the Spring of 1944, no FM programs were available to the public in the State of Georgia. With this fact in mind, the writer and Ben Akerman, Chief Engineer of Broadcast Station WGST, met in April, 1944, to formulate a plan which would bring FM broadcasting to the people of Georgia. The ideas originating in this meeting were crystallized in the following proposal presented by the writer to the Radio Committee of the Regents of the University System of Georgia in June, 1944.

PRELIMINARY PROPOSAL FOR PROGRAM OF RESEARCH IN THE FIELDS OF FREQUENCY MODULATION AND TELEVISION

In the light of present activity and interest in frequency modulation, facsimile, and other applications of radio transmission, the time has come for Georgia Tech to take a position of leadership in these fields and to protect its investment and earning capacity in the amplitude modulation facilities (WGST) it now operates. This can be achieved through an organized, definite program of research.

Herewith is submitted a workable, minimum program of research that will assure the achievement of these objectives. It is felt that the Communications Engineering Division of the Electrical Engineering Department at Georgia Tech is the logical fountainhead of any program of development in this field. With the cooperation of the engineering department of the Georgia Tech Station, WGST, the services of qualified technicians will be available to carry out a program of research dictated by the needs of this region.

All investigations in frequency modulation and television are at present being carried out by private firms, with the results utilized for their own, or military purposes. There is a distinct need in this area for research in the following fields of investigation:

(1) Propagation characteristics of frequency

modulation and television signals in the State of Georgia.

(2) Studies of antenna design to determine the most efficient types and locations.

(3) Measurements to determine the capabilities of the new forms of transmission.

(4) Equipment design, construction, and maintenance for frequency modulation and television.

(5) Methods of personnel training for the new fields.

Little information is at present available either to WGST or to Georgia Tech on any of the above subjects.

OUTLINE OF PROGRAM

A. Objectives

(1) General: To gather information about and to study propagation characteristics of FM and Television signals in the State of Georgia.

To obtain engineering knowledge about FM and Television equipment.

To provide undergraduate and graduate programs of instruction in these new fields.

(2) Specific: To experiment with various

types of antennas, various locations for antennas, etc.

To make field-strength and signal-to-noise measurements in the service area.

To arrange for program experimentation by cooperating with interested groups.

To survey FM set owners for listener reaction.

To impart to the present WGST engineering staff and to the Georgia Tech instructors the necessary knowledge for the correct operation of an FM station, and for the instruction of students and future WGST personnel.

To cooperate with firms and engineering societies already in the field for the advancement of the art.

To make available to interested groups periodic reports as to the progress of the investigations through publications of the Experiment Station.

B. Governing Committee

(1) It is felt that the Governing Committee should include the following technical personnel:

Dean of Engineering

Director, Georgia Tech Experiment Station

Head of Communications Engineering Division

Chief Engineer of WGST

C. Cost

(1) Equipment:

FM Transmitter	$10,000
Antenna	1,000
Frequency Monitor	750
Measuring Equipment	2,250
Installation	2,000
Studio	1,000
TOTAL	$17,000

(2) Maintenance of the program and operation of the facilities will cost approximately $10,000 annually.

It is proposed to operate the frequency modulation station on an experimental basis exclusively, and to initiate research in the field of television as soon as conditions warrant such a program.

The information and experience gained through the operation of this experimental station will be of direct commercial value to WGST at such time as it enters the field of commercial FM operation.

It is believed that the general public in this area

will be encouraged to buy FM receivers if a local FM station is placed in operation. Thus, a potential commercial audience will be ready for the day when WGST enters the FM field. If the general public buys FM receivers, a new market will be created which will help business in this area.

APPLICATION FOR THE CONSTRUCTION PERMIT

The proposal for a program of research in FM and television was approved by the Board of Regents at its meeting in Milledgeville, Georgia, on August 31, and September 1, 1944. The Regents authorized the allocation of $10,000 to the Georgia School of Technology for instructional purposes in radio engineering and research work in frequency modulation, television, and other radio fields. The Regents also authorized the allocation of $17,000 for the purchase of the necessary equipment.

The General Rules and Regulations of the Federal Communications Commission, Part 2, require that a "Construction Permit" be obtained before authority is granted to install a Developmental Broadcast FM Station. The application for the construction permit is submitted in duplicate to the Federal Communications Commission, Washington, D.C., on FCC Form No. 309.

An application for a construction permit requires careful study by a qualified radio engineer, and is a task usually assigned to a consulting radio engineer who specializes in this work. Due to the nature of the problem, no standard answers can be prepared for the many questions asked in the application.

A copy of the complete application for the construction permit for a Developmental Broadcast FM Station appears in the following section.

F. C. C. Form No. 309

8

Form Approved:
Budget Bureau No. 52.R022.2

File No. .....

UNITED STATES OF AMERICA *Call letters* .....

FEDERAL COMMUNICATIONS COMMISSION

APPLICATION FOR { RELAY / INTERNATIONAL / TELEVISION / FACSIMILE / HIGH FREQUENCY / EXPERIMENTAL / DEVELOPMENTAL BROADCAST. X } BROADCAST STATION CONSTRUCTION PERMIT OR MODIFICATION THEREOF

(Check type of station)

(Submit in duplicate to the Federal Communications Commission, Washington, D. C.) *(Swear to one copy)*
(See rules governing the service in which authorization is sought before executing application)

To the Federal Communications Commission:

1. Name of applicant *..... Georgia School of Technology .....

2. Post-office address: State ..... Georgia ..... City ..... Atlanta .....

Street and number ..... 225 North Ave., NW .....

3. What is applicant's principal business? ..... Technological School .....

(*a*) What other business or businesses is applicant directly or indirectly interested in? Explain fully.

.....

.....

.....

.....

(*b*) If applicant is a corporation, give the names and addresses of the officers, directors, and principal stockholders and state specifically what other business or businesses each of these parties is directly or indirectly interested in. Explain fully (Attach additional sheets if necessary.)

.....

.....

.....

.....

4. Is applicant a citizen of the United States? .....

If so, state whether by birth or naturalization .....

5. Is the applicant a representative of an alien or foreign government? ..... No .....

6. State whether applicant is a corporation, partnership, or association ..... Unit of University System of Georgia under control of

7. If applicant is a corporation— Board of Regents created by an act of Georgia Legislature in 1931.

(*a*) Under laws of what State or country is it organized? .....
(A copy of the articles of incorporation properly certified by the Secretary of State shall be attached if not heretofore filed with the Commission)

(*b*) Is more than one-fifth of capital stock owned of record or may it be voted by aliens or their representatives or by a foreign government or representative thereof, or by any corporation organized under the laws of a foreign country? .....

(*c*) Is any director or officer an alien? ..... If so, state name, citizenship, and position of each .....

.....

.....

* If a corporation, state corporate name; if a partnership, state names of all partners and the name under which the partnership does business; if an unincorporated association state the name of an executive officer, the office held by him, and the name of the association. The same name or names should be signed in the place provided at the end of application, except that in the case of a partnership, the application may be signed in the name of the partnership by one of the partners.

(*d*) Give names, addresses, and citizenship of (1) incorporators, (2) directors, (3) officers, and (4) stockholders; the offices held by each officer and the number and kind of shares and percentage of issued stock held by each stockholder; *Provided, however,* That if the licensee has one thousand stockholders or more, a list of only the stockholders owning one percent or more should be given. (If this information in complete form is now on file and there is no change, reference thereto may be made.)

INCORPORATORS

Name	Address	Citizenship

DIRECTORS

Name	Address	Citizenship

OFFICERS

Name	Address	Office	Citizenship

STOCKHOLDERS
(Use additional sheets if necessary)

Name	Address	Citizenship	Number of shares and percentage of issued stock held

(*e*) Is stock to be sold after this permit is issued for purpose of raising money to construct and/or operate the proposed station? .....

8. If applicant is a corporation, is applicant directly or indirectly controlled by any other corporation?

.....

(*a*) If so, give name and address of such controlling corporation .....

.....

(*b*) Under laws of what State or country is such corporation organized? .....

(A copy of the articles of incorporation properly certified by the Secretary of State shall be attached if not heretofore filed with the Commission)

(*c*) Is more than one-fourth of capital stock of such corporation owned of record or may it be voted by aliens, their representatives, or by a foreign government or representative thereof, or by any corporation organized under the laws of a foreign country? .....

(*d*) Is any director or officer of such corporation an alien? .....

If so, state name, citizenship, and position of each .....

(*e*) Give names, addresses, and citizenship of (1) incorporators, (2) directors, (3) officers, and (4) stockholders; the offices held by each officer and the number and kind of shares and percentage of issued stock held by each stockholder; *Provided, however,* That if the licensee has one thousand stockholders or more, a list of only the stockholders owning one percent or more should be given. (If this information in complete form is now on file and there is no change, reference thereto may be made.)

INCORPORATORS

Name	Address	Citizenship

DIRECTORS

Name	Address	Citizenship

OFFICERS

Name	Address	Office	Citizenship

STOCKHOLDERS

(Use additional sheets if necessary)

Name	Address	Citizenship	Number of shares and percentage of issued stock held

(*f*) Is the above-described controlling corporation in turn a subsidiary? .....
If so, attach additional sheets answering question 8 (*a*) to (*e*), inclusive, for each company to and including the organization having final control.

9. If application is made in behalf of a copartnership, there must be submitted a certified copy of the articles of copartnership. (If articles have heretofore been filed with the Commission, reference thereto may be made.) .....

10. If application is made in behalf of an unincorporated association, there must be submitted a certified copy of the articles of association and bylaws (unless heretofore filed with the Commission), showing the purpose of the association .....

Applicant must also show—

(*a*) The names, addresses, and citizenship of the officers and the offices held by each .....

(*b*) The number of members .....

(*c*) Whether any members are aliens .....

(*d*) The name, citizenship, and position of each alien .....

11. (*a*) Is applicant directly or indirectly, through stock ownership, contract, or otherwise, interested in the ownership or control of any other radio broadcasting station? Yes

If so, state call letters and location of such stations WGST and WGER
Atlanta, Georgia

(*b*) Has the applicant in the past been directly or indirectly interested in the ownership or control of any radio broadcasting stations? Yes

If so, state call letters and location of such stations WGET - Relay Broadcast
Georgia School of Technology, Atlanta, Georgia
(License expired)

12. (*a*) State applicant's relation to station (whether applicant is to be owner or lessee, and, if neither owner nor lessee, state nature of applicant's interest in use and control of station) Owner

(If not owner, a copy of agreement showing applicant's interest in station must be attached if not heretofore filed with the Commission)

(*b*) If applicant is not to be owner of station, who is? .....

(*c*) Will applicant have absolute control of station, as to physical operation, experimentation, and programs broadcast? Yes

If not, attach copy of any contract which may in any way affect applicant's right to do so.

13. Attach detailed financial statement showing applicant's assets and liabilities and state fully the facts showing applicant's financial responsibility with respect to the construction and operation of station.
See EXHIBIT "A"

14. (a) Has the applicant been finally adjudged guilty by any Federal court of unlawfully monopolizing, or attempting unlawfully to monopolize, radio communication directly or indirectly through control of manufacture or sale of radio apparatus, exclusive traffic arrangements, or any other means, or of unfair methods of competition? No

(b) Is applicant directly or indirectly controlled by any party finally adjudged guilty as above stated?

No
(Answer yes or no)

15. The class of broadcast station for which application is made is (indicate by check mark)—

Relay.
International.
Television.
Facsimile.
High Frequency.
Experimental.
Developmental Broadcast. X

16. Is this application made for authorization to—

(a) Construct new radio station? Construct new radio station

(b) Change present location of transmitter of existing station?

17. The frequencies or band requested and particulars of operation of the proposed station are as follows:

Frequencies [1] (kc)	Hours [2]	Maximum power [3] (watts)	Emission [4]	Modulating frequency [5] (cycles)
47,500	Unlimited	1000	Special FM	15,000
or any frequency				
assigned by the FCC				

[1] List frequencies separately.
[2] Indicate as unlimited, day only, etc.
[3] Maximum rated carrier power of transmitter.
[4] A$_1$, A$_2$, and/or special. List each type of emission separately for each frequency. Describe special emission in space for remarks below.
[5] Give maximum modulating frequency employed in normal operation opposite type of emission involved.

REMARKS: Normal band-width plus and minus 75 kc FM. Experimental work to be done with sinusoidal tone, two or more modulating tones simultaneously present, square waves and pulses.

18. Attach details of the program of research to be made as follows: See EXHIBIT "B"

(a) Complete outline of all research, experiments, and tests.
(b) Qualifications of engineers supervising research and taking observations.
(c) Results expected and detailed bases therefor.
(d) Any other pertinent information required by the rules governing the particular class of station.
(e) For stations above 30,000 kc, see Section 4.4(e).

19. Description of transmitting apparatus proposed to be installed (if more than one transmitter is to be used attach separate description of each)— Data on file. No change.

(a) Make Western Electric Type or model No. 503 A-1

(b) Oscillator: Type of circuit ..... Number, manufacturer's name, and type of tubes ..... Normal plate current, per tube ..... Plate voltage .....

(c) List buffer and intermediate power amplifier stages, by number, manufacturer's name, and type of tubes in each stage .....

(d) Last radio stage: Number, manufacturer's name, and type of tubes ..... Normal operation for power requested: Plate current, per tube ..... Plate voltage .....

(e) Modulator or last audio stage: Number, manufacturer's name, and type of tubes ..... Normal plate current, per tube ..... Plate voltage .....

(f) Which radio stage is modulated? .....

(g) What system of modulation is employed (high level, low level, grid bias in last radio stage, etc.)? .....

(h) If low-level modulation is employed, give for modulated radio stage—

Number, manufacturer's name, and types of tubes .....

Plate current, per tube ..... Plate voltage .....

(i) The transmitter is designed for what maximum percentage of satisfactory modulation? .....

20. (a) Describe the plate power supply for last radio stage .....

Rated: Current ..... Voltage .....

(b) Maximum operating carrier power output of transmitter for satisfactory operation is ..... watts.

21. (a) State what apparatus is included as an integral part of the transmitter that will automatically hold frequency within the required limits Crystal oscillator & frequency synchronizer

Within how many cycles of the assigned frequency is this apparatus designed and guaranteed to hold the operating frequency? Within plus or minus 1000 cycles

(b) State manufacturer's name and type number of frequency monitor An acceptable frequency monitor will be purchased as soon as available.

(1) Give the manufacturer's rated accuracy of the frequency monitor .....

(2) How often will the station frequency and monitor be checked with established frequency standard? Every 30 days against WWV

22. Applicant represents (1) that there is attached or (2) that there has been heretofore filed with the Commission, an accurate schematic diagram of the fundamental radio and audio circuits of the transmitter proposed, including antenna and ground or counterpoise connections, antenna feed system, and that it indicates the type of tubes.

(This should be a blueprint or ink drawing, and, if possible, the size of this application, and attached hereto.) Data on file.

23. (a) Type of antenna Experimental

(b) Height of vertical lead ..... feet.

(c) Length of flat top (if any) ..... feet.

(d) If not fully described above, give complete details Experimental for research purposes.

(e) Counterpoise (if used)—type and dimensions None

(f) Antenna ground (if used)—how obtained? None

(g) Attach full description of the special features of proposed antenna system and developments thereof. See EXHIBIT "C"

(h) Give maximum height (in feet) of towers above ground level Not over 150 feet

(i) Will towers be painted and marked with signal lights to conform with specifications of Department of Commerce (see Aeronautics Bulletin No. 474)? See EXHIBIT "C"

24. Cost of proposed station: Transmitter, $ 12,000.00 Studio, $ 1,000.00

Other items (state nature) Speech input, frequency monitor, and measuring equipment 5,000.00

25. (a) Proposed location of transmitter (all classes except portable or mobile relay):

State Georgia County Fulton City or town Atlanta

Street and number 225 North Avenue, NW

N. latitude: Degrees 33, minutes 46, seconds 20

W. longitude: Degrees 84, minutes 23, seconds 43

(b) If relay: Portable Mobile

Area in which station is to be used

26. Number of persons residing within various distances of proposed location of transmitter is as follows: See EXHIBIT "D"

0.4 mile 7657, 1 mile 39213, 2 miles 156963 3 miles 2051095 miles 231655, 8 miles 295779

27. (a) Number of all classes broadcasting stations relay broadcast (by call letters) located within various distances of proposed location of transmitter is as follows: See EXHIBIT "D"

1 mile WATL, 2 miles , 3 miles , 8 miles WGST & WATL, WAGA & WSB Aux.

(b) Number of nonbroadcasting (commercial or government) RECEIVING stations located within various distances of proposed location of transmitter is as follows:

1 mile , 2 miles , 3 miles

28. (a) Name and give location of all AIRPORTS within 10 miles of proposed location of transmitter.

See EXHIBIT "D"

Candler Field, 8 miles south of transmitter on Fulton-Clayton County line.

(b) Give distance from proposed location of transmitter to each of such airports

Candler Field - 8 miles

(c) Name and give distance to any established AIRWAYS within 10 miles of proposed location of transmitter Six miles from Atlanta to Nashville airway.

Seven miles from Atlanta to Spartanburg airway.

(d) If application is for new station or change of location of existing station, attach map showing present location, proposed location, character of surrounding area (retail or wholesale business, manufacturing, residential, or unpopulated, the heights of all tall buildings, if any, in the vicinity of the antenna, indicating the distance and direction thereof from the proposed site; also, density of population, type of soil and terrain), and the location of airports, airways, and other radio stations, including receiving stations, except broadcast or amateur. See EXHIBIT "D"

29. Outline plans for programs Programs will be transmitted for experimental purposes only.

30. If the construction permit is granted, the construction will be commenced within 30 days of the granting thereof and will be completed and the station ready for operation within 120 days thereafter.

31. The applicant waives any claim to the use of any particular frequency or of the ether as against the regulatory power of the United States because of the previous use of the same, whether by license or otherwise, and requests a construction permit in accordance with this application.

Dated this ..... day of ....., 19.....

Georgia School of Technology
(Must correspond with item 1) *Applicant.* †

By .....

Official.

Subscribed and sworn to before me this ..... day of ....., 19.....

[SEAL]

(Notary public's seal must be affixed where law of jurisdiction requires, otherwise state that law does not require seal.)

Notary Public.

My commission expires .....

† Must be subscribed and verified by party applicant, by one of the parties if more than one, by an officer if applicant is a corporation, or by attorney of applicant only under the provisions of Section 1.121 which must be fully explained.

(BE SURE ALL NECESSARY INFORMATION IS FURNISHED)

LIST OF EXHIBITS ATTACHED

EXHIBIT "A": Letter from the Secretary of the Regents of the University System of Georgia.

EXHIBIT "B": Answers to Item 18 (a, b, c, d).

EXHIBIT "C": Answers to Item 23 (g, i).

EXHIBIT "D": Answers to Items 26, 27 (a) and 28 (a, b, c, d).

EXHIBIT "E": Letter from Dr. G. A. Rosselot, Director, State Engineering Experiment Station, with regard to WPB priority.

EXHIBIT "A"

(Copy)

October 26, 1944

President Blake R. Van Leer
Georgia School of Technology
Atlanta, Georgia.

My dear President Van Leer:

The Board of Regents at its meeting in Milledgeville, Georgia on August 31, and September 1, 1944, authorized the allocation of $10,000 to the Georgia School of Technology for instructional purposes in radio engineering and research work in frequency modulation, television, and other radio fields. The board also authorized the allocation of $17,000 for the purchase of necessary equipment.

This money is available to the Georgia School of Technology in the usual manner of making budgetary requests for funds.

This letter will serve to authorize you to sign in the name of the Georgia School of Technology applications or other required papers to carry on research work in frequency modulation, television, and other studies in radio and to do all proper or necessary things for this institution to do this work as authorized.

Yours very truly

(Signed) L. R. Siebert

L. R. Siebert
Secretary

LRS:LW

EXHIBIT "B"

18 (a) and (c):

I. The Communications Engineering Division of the Electrical Engineering Department will pursue a program of research in FM in cooperation with the State Engineering Experiment Station. The results of the research will be published in the Bulletins of the Experiment Station.

II. All of the laboratory equipment and facilities of the Georgia School of Technology including those of the Engineering Experiment Station are available for use in this program of research.

III. The transmitter will be installed in a room adjoining the Communications Engineering laboratories of the Electrical Engineering Department at the Georgia School of Technology.

IV. Heretofore, practically no experimentation on the propagation of FM signals has been carried on in this area.

There is a great need for this type of information in Georgia for the educational and commercial groups who plan to install FM systems after the war.

It is planned, therefore, to carry on research, initially, along these lines as follows:

1. Various types of transmitting antennas will be installed and field-strength surveys will be made in order to determine the types of antennas that will give best coverage over the type of terrain in this area. (See EXHIBIT "C" - Answer to Item 23(g).

2. Various receiving antennas will be tried in the different surrounding sections in order to determine the types which will operate most effectively. This information will be of great benefit both to the FM receiving set owner as well as to the commercial FM interests.

3. It is planned to compare vertically and horizontally polarized transmission in an effort to obtain information of value to mobile radio systems, such as, police radio.

4. It is planned to compare FM transmission on higher frequencies with that in the 40 to 50 megacycle band.

5. It is planned to compare booster operation with vertical and horizontal polarization.

6. Since the static level in this area is high, it is planned to evaluate the performance of receivers with regard to their noise-rejecting qualities.

7. The transient performance of FM systems will be tested, utilizing the square-wave testing technique.

8. Spurious reflections from buildings and from Stone Mountain and Kennesaw Mountain will be evaluated by the use of pulse modulation.

V. Through the Engineering Experiment Station, the FM station will act as a "workshop" where the problems of other stations installed in this area can be solved by examination of the information resulting from the research program.

This research program is the beginning of a comprehensive program of research in radio which will be expanded into research in television and any other allied radio fields where need for research is apparent.

The Georgia School of Technology, an impartial, non-commercial institution, will be pleased to cooperate with the Federal Communications Commission in properly evaluating techniques and equipment as to performance in the interest of the general public.

18 (b)

1. The program of research will be under the supervision of Dr. G. A. Rosselot, Director, Engineering Experiment Station.
   The FM research will be conducted by Professor M. A. Honnell, Head of the Communications Engineering Division of the Electrical Engineering Department at Georgia Tech.
   Mr. Ben Akerman, Chief Engineer of Broadcast Station WGST, will act as Broadcast Consultant.
2. The Communications Engineering faculty and graduate students will participate in the program of research insofar as is consistent with the rules and regulations of the Federal Communications Commission.

18 (d): Supplementary statement and showing required by the Federal Communications Commission regulations regarding Developmental Broadcast Stations.

I. It is understood by the applicant that:

(1) All operation on the frequencies requested will be on an experimental basis.

(2) That the granting of the authority requested shall not be construed as a finding on the part of the Commission:

(a) That the frequencies authorized are the best suited to the particular purpose to be served by the station;

(b) That in the event the experimentation proves successful, either the particular frequencies authorized or any others will be allocated to the service developed for use on a permanent or commercial basis;

(c) That the applicant is qualified to operate a station in the service on any basis other than experimental;

(3) That the applicant desires and is willing to conduct and finance the experimental program with the full knowledge and understanding of the provisions of this section.

II. It is necessary to have an FM Experimental Station in order to conduct investigations into the propagation characteristics of signals

in the frequency modulation broadcast band especially with regard to reflection of signals from mountains and buildings in this area; to measure the audio-frequency distortion resulting from these abnormalities; to determine the relative advantages and disadvantages of horizontal and vertical polarization; to experiment with directive antennas to improve coverage in this band; and to use booster stations to give additional coverage in urban areas.

III. The operation of this station will be in the public interest, because of the need in this area for the information that will result from the research plan as proposed.

The results of this research will be made available to interested parties through publications of the State Engineering Experiment Station.

EXHIBIT "C"

23(g): 1. It is planned to erect both vertically and horizontally polarized antennas of the simpler types, such as, horizontal crossed dipoles and vertical co-axial antennas to directly compare the effectiveness of these antennas for reception at fixed locations and in automobiles.

2. Horizontally polarized antennas of the multi-element type, such as, the turnstile, will then be employed.

3. It is hoped that a practical vertically-polarized antenna with a reasonable gain can be developed.

The Electrical Engineering Department has constructed multi-element antenna models driven by a klystron operating on a frequency of 3,000 megacycles for experimental work within the Communications Laboratory. It is hoped that a small-scale model antenna can first be developed and tested at this frequency and then used for FM broadcasting.

23(i): The towers to be erected will be experimental and will not exceed the height of the smoke stack and the steeple on the main building on the campus located as described in EXHIBIT "D".

Should changes be made, the tower will be painted and marked to conform with specifications of the Civil Aeronautics Administration.

EXHIBIT "D"

POPULATION STUDIES AND MAPS REQUIRED BY QUESTIONS 26, 27(a) and 28(a), (b), (c), (d)

PROPOSED DEVELOPMENTAL BROADCAST STATION FOR THE GEORGIA SCHOOL OF TECHNOLOGY, ATLANTA, GA.

Prepared by

Ben Akerman

EXHIBIT "D"

POPULATION STUDIES -

The 1940 census figures were used. The census minor civil division map was used for rural areas and a census tract of the Atlanta Metropolitan area was used for urban areas. Uniform population distribution was assumed in each unit area, that is nine tenths of the area of a unit was assumed to have nine tenths of the population of that particular area.

The figures from this census studies are as follows: Persons within 0.4 miles 7,657, within 1 mile 39,213, within 2 miles 156,963, within 3 miles 205,100, within 8 miles 295,779.

MAPS -

Map No. 1 is a city map showing the city within about one and one half mile of the proposed transmitter location. The areas are marked with cross hatching as designated on the map to indicate the use of the areas under consideration. The unmarked areas are vacant, thinly populated, or semi-vacant business, such as parking lots, storage yards, etc. The scale of this map is noted by the one mile circle centered on the proposed transmitter location.

The proposed transmitter location is in the Electrical Engineering Building on the campus of the Georgia School of Technology. This building is located on Cherry Street between North Avenue and Ponce de Leon Avenue.

The area to the north for approximately one half mile is the Georgia Tech campus; to the west is principally business, wholesale and light manufacturing areas; to the south are located several government housing projects (Techwood Homes and Clark Howell Homes), beyond this is the main part of the city; to the east is the Georgia Tech campus (two blocks), several blocks of business and then residential areas.

Map #2 is a map of a portion of Fulton County showing the location of the airport, the airways and the transmitter of WGST, WAGA, WATL and the auxiliary transmitter of WSB.

The type of soil is fairly uniform, sandy clay without cropping of rock formations. The terrain is rolling hills.

The map of the city is not to a scale that would permit the showing of buildings in the vicinity of the proposed transmitter location. The Academic Building about 500 ft. E. N. E. of the proposed location has a tower, the top of which is approximately 175 ft. above the ground level at the proposed location. About 1000 ft. N. E. from the proposed location is the smoke stack of the Georgia Tech Power Plant. This stack is about 175 ft. above the ground level at the proposed location. The other buildings in the vicinity do not exceed four stories in height.

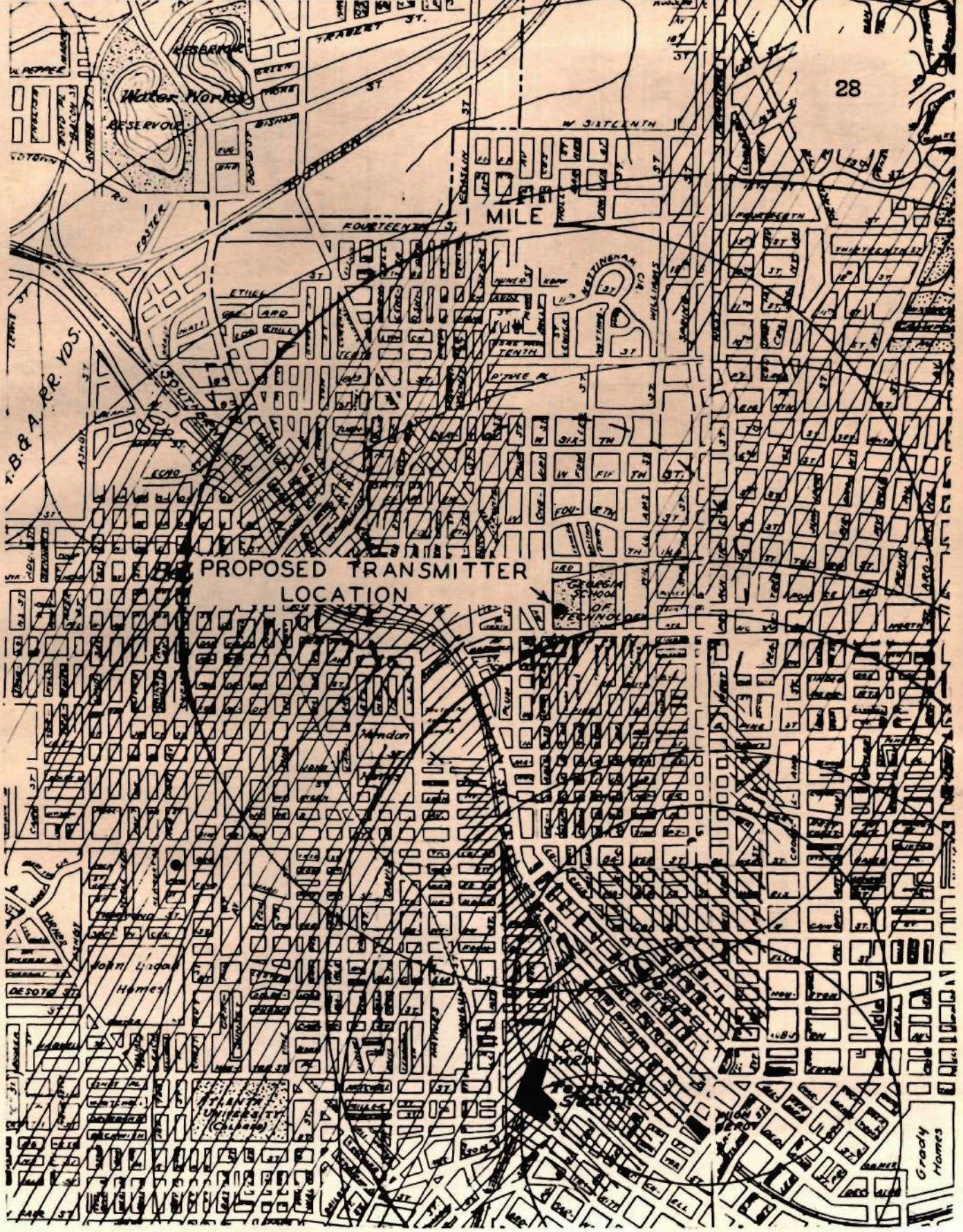

Fig. 1 - Map No. 1 Showing Transmitter Location in City of Atlanta

MAP NO. 1

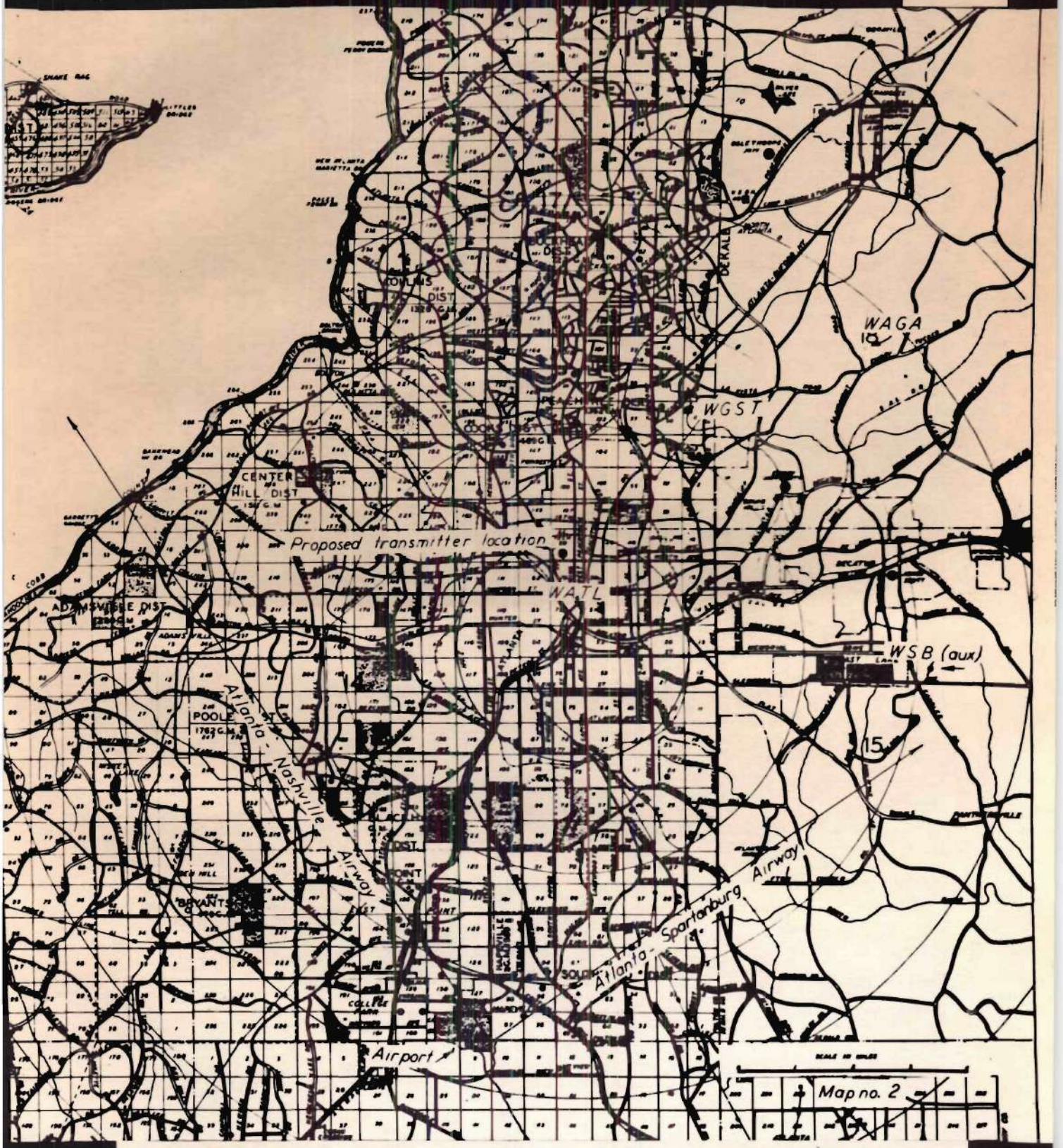

Figure 2 - Map No. 2 Showing Location of Airways and other Broadcast Stations in Fulton County.

EXHIBIT "E"

(Copy)

November 1, 1944

Federal Communications Commission
Washington, D. C.

Gentlemen:

In connection with our application for a frequency modulation station construction permit, the equipment will be purchased under WPB order P-43, serial number 73.

An order has already been placed with the proper priority for the transmitter.

Yours very truly

(Signed) G. A. Rosselot

Gerald A. Rosselot
Director

GAR/mas

THE CONSTRUCTION PERMIT

The Federal Communications Commission granted a construction permit to the Georgia School of Technology on January 25, 1945, for a Developmental Broadcast FM Station. The permit is issued "subject to the provisions of the Communications Act of 1934, subsequent acts, treaties, and all regulations heretofore or hereafter made thereunder, and further subject to the conditions set forth in this permit".

The construction of the station must be started within a maximum of 60 days from the date of granting of the permit, and must be completed within a maximum of six months thereafter. The specific regulations governing the construction of the station are given in Part 2 of the Rules and Regulations of the Federal Communications Commission.

The station was assigned the call letters W4XAG. Temporary permission was granted to use the frequencies of 49,900 kilocycles, 49,700 kilocycles, 49,500 kilocycles, 99,800 kilocycles, 99,400 kilocycles and 99,000 kilocycles. It was decided to use a frequency of 49,500 kilocycles until the transmitter purchased could be converted for operation at the higher frequencies.

THE FLOOR PLAN

As soon as the Construction Permit was granted by the Federal Communications Commission, the necessary rooms for the FM station were built adjacent to the Communications Laboratories on the third floor of the Electrical Engineering building. This location was chosen for the following reasons:

(1) The measuring equipment and other instruments in the Communications Laboratories are readily accessible for use in the FM station.

(2) The roof of the building is flat, and can support a tower with no additional bracing.

(3) The necessary transmission line length from the transmitter to the antenna is a minimum.

(4) The Electrical Engineering building is located on a point of high elevation.

Fig. 3 shows the floor plan of the FM station and the adjacent Communications Laboratories. The walls and the ceilings of the reception room, the transmitter room and the work room are made of Celotex, and the floors are covered with asphalt tile. The studio is described in the following section of this report.

During five months of the year, the ambient temperature in the FM station rarely drops below 80 degrees Fahrenheit either day or night. It is planned, therefore, to install air-conditioning equipment for the protection of the transmitting and speech-input apparatus as well as to provide adequate ventilation for the studio. The arrangement of the rooms with only one window in the work room is ideal from the air-conditioning viewpoint.

All rooms are planned on a basis of maximum utility for the Electrical Engineering Department research and undergraduate teaching and laboratory programs. There is a small, but useful, library in the reception room, which is used as a reference room by senior and graduate students working on research projects. The studio is used to demonstrate sound and acoustical phenomena to undergraduate Communications Engineering classes.

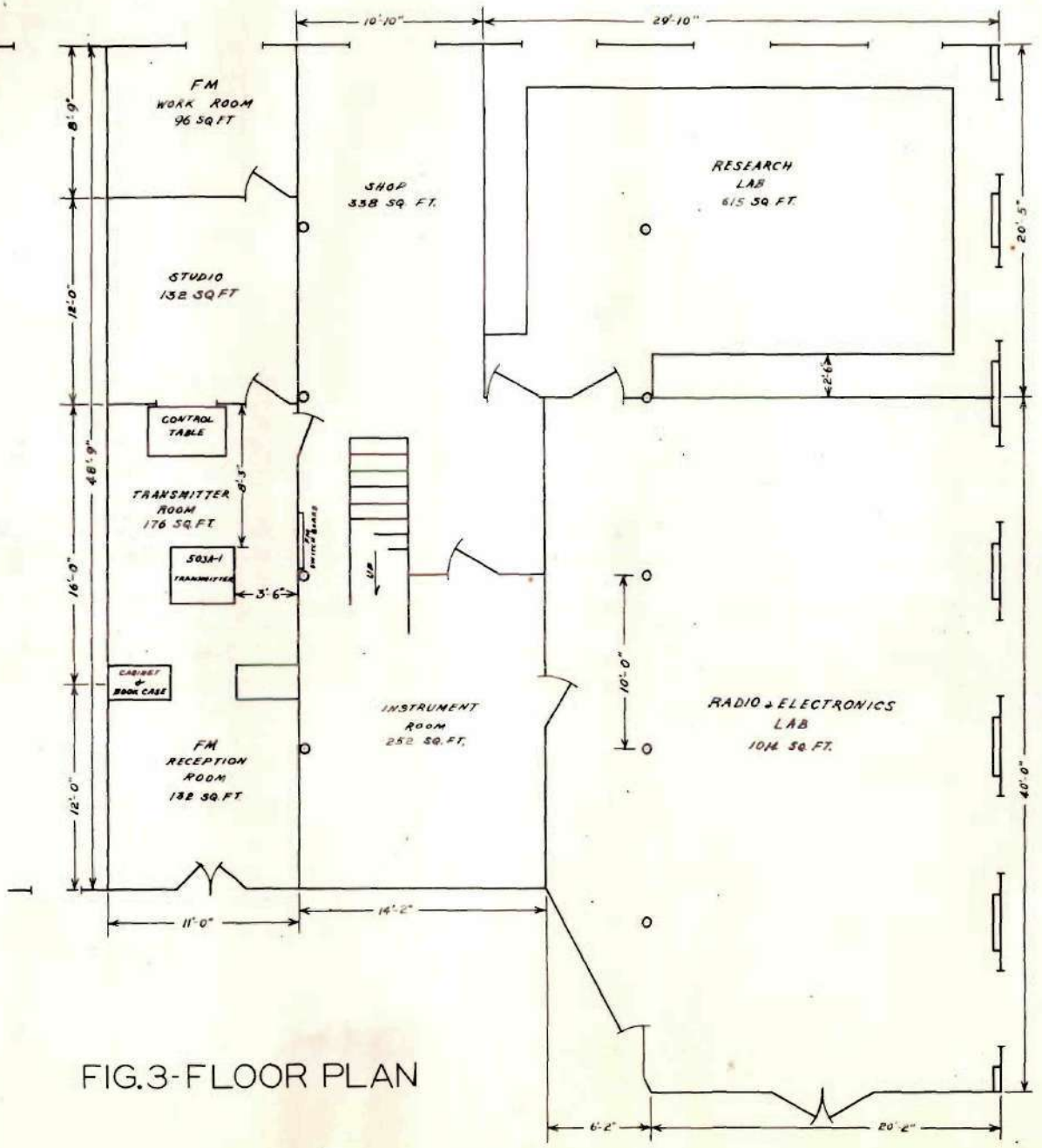

FIG. 3 - FLOOR PLAN

THE STUDIO

The studio is designed to provide a quiet place in which to make station announcements and in which to listen critically to the programs transmitted by the station. The studio walls and the ceiling are properly treated to reduce the reverberation time to an acceptable value.

The floor of the studio is covered with asphalt tile. All walls and doors are covered with Celotex with the rough side outward. The ceiling and a band three feet wide at the top of the walls are covered with Acousti-Celotex fastened to three-inch furring strips. Additional Acousti-Celotex is on hand in the event that it is desired to change the acoustical characteristics of the studio. The studio window is made of two pieces of glass separated two inches in order to reduce sound transmission through the window.

The studio is 11 feet wide, 12 feet long and 10 feet high. This represents a size too small to originate musical programs. The cost of a studio of FM quality properly insulated from the excessive vibration caused by the power machinery laboratory is prohibitive. Direct program lines to the studios of radio station WGST provide all of the necessary program facilities for the planned research.

The calculated reverberation time for the studio

is 0.5 second. According to the information in Albert's Electrical Communication, this reverberation time is an optimum value both for a studio and for an audition room.[1] Noise conduction through the floors is quite severe when the machinery laboratory on the second floor of the building is in operation.

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[1] Albert, A. L., Electrical Communication, John Wiley & Sons, Inc., pp. 21-37, 1940.

THE ANTENNA AND GROUND SYSTEM

It is not the primary purpose of the FM research project to provide a maximum coverage of listener area. The relative advantages obtainable through the use of standard multi-element antennas of high elevation are well known.[2] The main condition to be fulfilled by an experimental antenna system is that it be readily accessible for experimental modifications. All antenna gain comparisons are readily made if the antenna is sufficiently remote from trees, buildings, or other obstructions.

The field gain of a multi-element antenna is the ratio of the field intensity developed at one mile with the antenna to the field intensity developed at one mile with a vertical half-wave antenna. Since a vertical half-wave antenna is used as a reference in the computation of the field gain of all other antenna types, it was decided to erect, initially, a vertical half-wave antenna of the coaxial type.

The antenna system is shown in Fig. 7. The center of the antenna is exactly 100 feet above the ground level. This places the center of the antenna at an elevation of 1080 feet above sea level.

The length of the antenna was properly adjusted by mounting the antenna on the end of a transmission line in

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[2]Taylor, J. P., "Antennas for FM Stations", Broadcast News, No. 39, pp. 6-13, August, 1944.

the laboratory. The antenna was extended through a window to place it well away from surrounding objects. The coaxial transmission line was a section 20 feet long of the type used on the tower with holes drilled through the outer conductor at six-inch intervals throughout the length of the line.

A laboratory transmitter was used to excite the antenna at the operating frequency of 49.5 megacycles. The standing waves on the transmission line were then measured by inserting the probe of a vacuum-tube voltmeter in the holes provided for that purpose. A standard technique was employed to adjust for optimum matching conditions.[3] When the ratio of the maximum to the minimum voltage on the line was within five per cent of unity, further adjustment of the antenna length was deemed unnecessary.

The coaxial transmission line feeding the antenna is made of hard-temper copper sections 20 feet long. The diameter of the outer conductor is 0.875 inch, and the diameter of the inner conductor is 0.25 inch. The line has a characteristic impedance of 67 ohms, a velocity of propagation equal to 97 per cent of free space velocity, and an efficiency of 92 per cent at a frequency of 100 megacycles for a section 100 feet long.

Low-loss glass cable terminals are installed at the two ends of the line. A pressure gage is provided at the

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[3]Terman, F. E., Radio Engineers' Handbook, McGraw-Hill Book Co., Inc., pp. 178-182, 1943.

transmitter end of the line to indicate the pressure of the dry air pumped into the line to reduce moisture condensation.

A short-circuited section of the coaxial line electrically one quarter of a wave length long is shunted across the transmission line at a point five feet above the roof of the building. This stub section provides a direct-current path between the line conductors for lightning protection, and at the same time it serves as a second-harmonic wave trap to reduce the magnitude of the second harmonic radiated by the antenna.

The external ground system is shown in Fig. 4. The tower is bonded to the metal roof at four points with four-inch copper strips 0.021 inch thick. Each corner of the roof is in turn grounded by means of four-inch copper strips which extend down the corners of the building. The strips are buried for a distance of 15 feet at a depth of two to three feet. The roof is also grounded at its midpoint with a conductor consisting of seven strands of No. 12 copper wire.

The internal ground system consists of a four-inch copper strip extending from the transmitter to the ground where the strip is buried for a distance of 15 feet at a depth of three feet. All conduits, rails and pipes in the building are strapped to this ground strip.

The extensive ground system is required due to the fact that the Electrical Engineering building is constructed completely of wood and brick. The external ground system serves to protect the building against lightning, while the internal ground system provides the necessary radio-frequency ground.

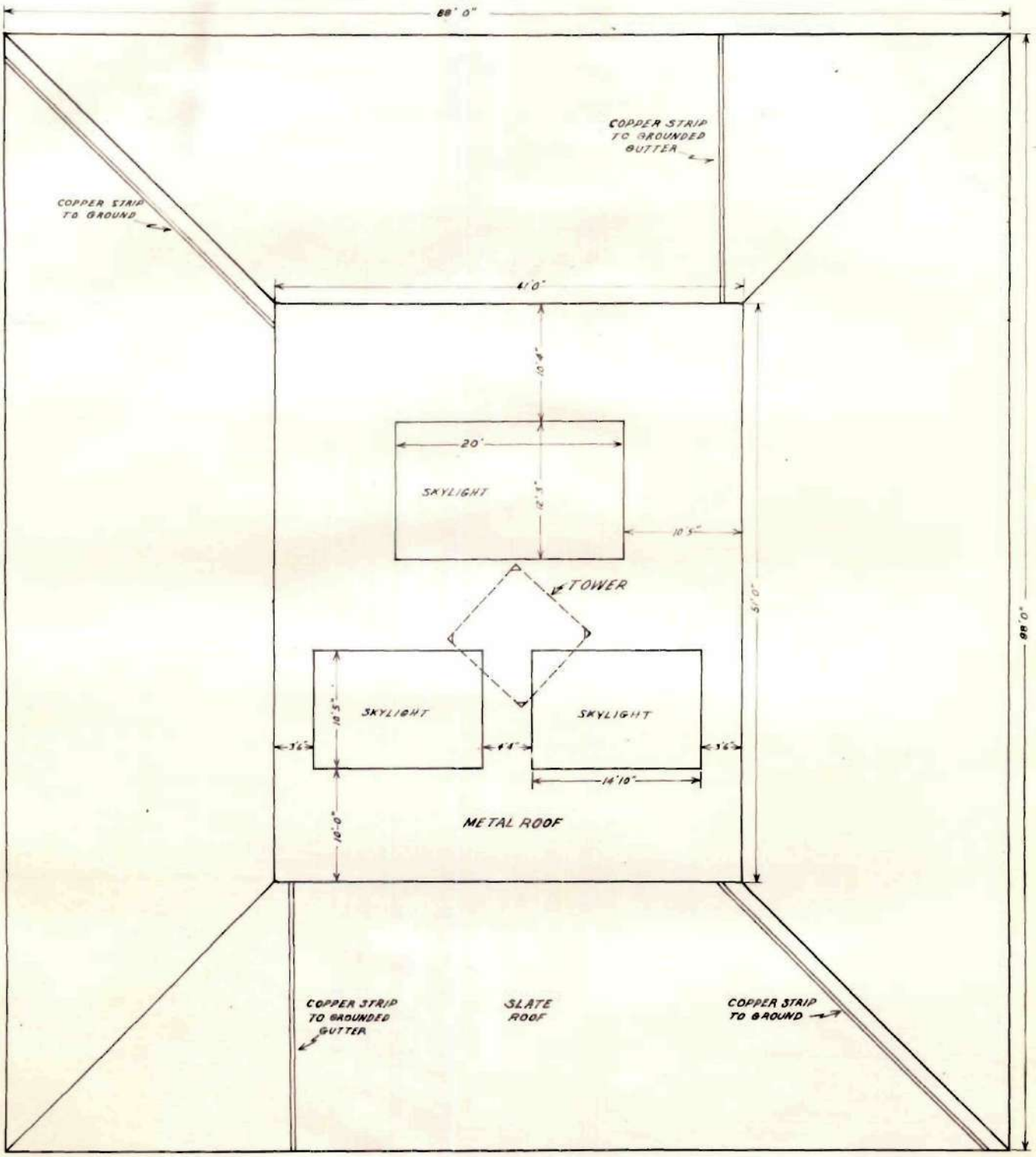

FIG. 4 - GROUND SYSTEM

M. A. Hannell
Ga. Tech

THE POWER FACILITIES

A 5-KVA, 2300 to 230-volt transformer located in the generator room on the first floor of the building supplies power to the transmitter and to the speech input equipment. Although 230-volt mains are available in the building, it is necessary to provide a separate transformer in order to reduce line-voltage variations caused by the machinery laboratory in the building. A constant-voltage transformer may be installed in the future, if variations in line voltage interfere with the field-strength measurements.

The power distribution panel is located in the room adjacent to the transmitter room. A three-wire line from the transformer supplies 115 volts and 230 volts for the operation of the equipment. The power distribution arrangement is shown in Fig. 5.

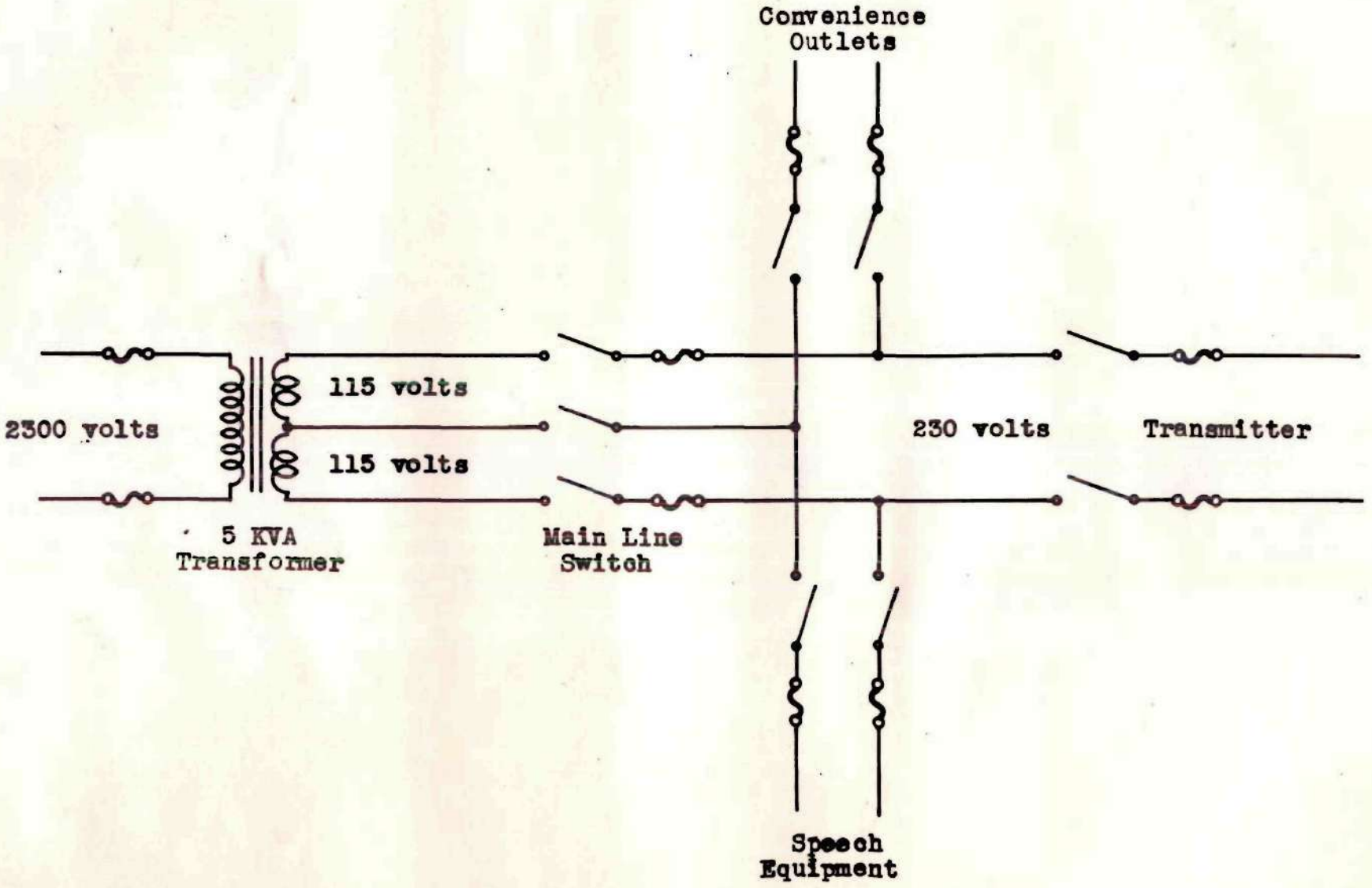

Fig. 5 - The Power Distribution System

THE TRANSMITTER

The transmitter is a Western Electric Type 503A-1 one-kilowatt frequency modulation transmitter employing the synchronized FM method of frequency control. This transmitter incorporates many excellent features which give it the following desirable characteristics listed by the manufacturer:

(1) The carrier frequency stability is at least twice as efficient as the present FCC requirements of plus or minus 2000 cycles.

(2) The transmitter provides improved high-quality and noise-free transmission through the use of a balanced modulated oscillator and a balanced control tube circuit.

(3) The transmitter is capable of linear modulation to plus or minus 100 kilocycles without critical adjustments at any audio frequency between 30 and 15,000 cycles per second.

(4) The unique use of negative feed back in the modulated oscillator minimizes distortion over a wide range.

(5) The accidental interruption of the carrier frequency control does not cause departure of the carrier from its assigned frequency.

(6) The carrier frequency control is completely isolated from the modulation and program circuits.

The theoretical operating principles of the transmitter are presented in a recent article by J. F. Morrison.[4] Complete installation blue prints and instructions for the transmitter are on file in the FM office.

The transmitter is in a single unit 78 inches high, 44 inches wide, and 39 inches deep, weighing approximately 2000 pounds. The transmitter unit is installed over a large wooden beam supporting the floor in order to distribute the weight properly. The tube complement used in the transmitter is outlined in the Station License application.

The complete electrical characteristics of the transmitter furnished by the manufacturer are as follows:

Frequency Range

The frequency range of the transmitter is from 42 to 50 megacycles.

Frequency Response

The transmitter is flat within plus or minus one decibel from 30 to 15,000 cycles per second.

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[4]Morrison, J. F., "A New Broadcast Transmitter Circuit Design for Frequency Modulation", Proc. I.R.E., vol. 28, pp. 444-449, October 1940.

Speech Input Level

A program level of approximately 0 VU is required for full modulation of plus or minus 100 kilocycles per second. A single frequency level of plus 8 VU is required for the same excursion.

Distortion

Typical measurements of root-mean-square audio-frequency harmonic distortion with a distortionless FM audio monitor in the frequency range of 30 to 15,000 cycles per second show less than 2% at a modulation corresponding to plus or minus 100 kilocycles excursion of the carrier. Distortion measurements include all audio-frequency harmonics up to 30,000 cycles per second.

Modulation Capability

Typical measurements of modulation capability show that the transmitter modulates to a degree corresponding to more than plus or minus 150 kilocycles per second at any frequency within the range of 30 to 15,000 cycles per second. The modulation action of this transmitter is independent of any carrier frequency stabilizing action and is also unrestricted as to the degree of modulation possible at any frequency including the extreme low end of the audio-frequency range. The modulation capability of this transmitter is unique among FM broadcasting equipments.

Noise Level

The circuit employed is not sensitive to noise producing action of any character, either of the amplitude or of the phase variation types. Typical measurements show that without special precautions against mechanical vibrations or electrical balances, that is, under conditions to be encountered in day-by-day commercial broadcasting, the phase noise carried by the transmitted wave is 70 DB down unweighted from plus or minus 100 kilocycles swing.

Frequency Stability

The frequency is maintained well within 1000 cycles per second of the assigned frequency without the use of temperature control anywhere in the system. This stability is entirely independent of circuit variations. Since the frequency synchronizer is external to the transmission path, no interruption in operation is caused by failure of a vacuum tube or any other component in the synchronizing circuit.

Pre-Emphasis of Audio Frequencies

A pre-emphasis circuit is provided at the audio-frequency input. This circuit is designed to have a constant impedance of 600 ohms for all frequencies and a response characteristic rising from 400 to 15,000 cycles per second in accordance with RMA standards.

THE SPEECH INPUT EQUIPMENT

The Western Electric 23C Speech Input Equipment provides adequate facilities for FM radio broadcasting from either one or two studios. Switching and mixing circuits are included to accommodate either eight studio microphones, or low output transcription tables, a control room announce and talkback microphone and four incoming program lines, or other medium level inputs. Complete instructions on the speech input equipment are on file in the FM office.

The characteristics of the 23C equipment supplied by the manufacturer are as follows:

MAIN SYSTEM

Gain

96 db through microphone channels.
64 db through program line channels.

Mixer Controls

20 steps. 17 steps of 1½ db each tapering to cut-off on the last three steps.

Master Gain

20 steps. 17 steps of 2 db each tapering to cut-off on the last three steps.

Operates From

Microphone circuits of 30 or 250 ohms.
Program line circuits of 600 ohms.

Internal Input Impedance

Microphone circuits open.
Program line circuits are 600 ohms.

Operates Into

600-ohm load.

Internal Output Impedance

600 ohms.

Distortion

Distortion of main amplifier at an output level (single frequency) of plus 18 db referred to one milliwatt is less than 3/4 of 1% at 5000 and 400 cycles and approximately 1% at 50 cycles.

Electrical Noise

Under normal operating conditions, referred to a single frequency output level of plus 18 db, the signal-to-noise ratio is 60 db with 78 db net gain, and this ratio increases as the gain is decreased.

MONITOR AMPLIFIER

Gain

51 db working from 600 ohms through input transformer T9. When connected to output of line amplifier for normal monitoring, output of monitor amplifier is approximately 18 vu above output of line amplifier.

Gain Control

19 steps of 2 db each and an "off" position.

Operates From

600 ohms when connected to external circuits.

Internal Input Impedance

600 ohms when used with input transformer T9 for monitoring external circuits.

Operates Into

750 ohms consisting of three 250-ohm loud speakers in series or combination of 250-ohm loud speakers and 250-ohm load resistors in series.

Internal Output Impedance

450 ohms.

Output Power

2.5 watts with approximately 5% distortion at 400 cycles. 1.5 watts with approximately 1% distortion at 400 cycles.

POWER SUPPLY

Alternating Current

105 to 125 volts, 50 to 60 cycles. Approximately 90 watts.

Direct Current

12 volts DC, 0.25 ampere for relay and signal light operation.

AUXILIARY SPEECH EQUIPMENT

A Western Electric No. 281A Program Line Panel is used in conjunction with the speech-input equipment to terminate the incoming program line from the WGST studios and to provide patching facilities for the outgoing program line to the FM transmitter. This panel contains a No. 23A Line Equalizer and a No. 119C Repeat Coil necessary for the proper equalization and termination of the program line. The line is equalized for a frequency response within one decibel up to 9000 cycles per second. Jacks are provided at appropriate points in the speech circuits for testing and bridging purposes. A bulletin describing the program line panel is on file in the FM office.

Two Jensen Type JAP-60 coaxial high-fidelity speakers mounted in bass reflex enclosures are used for program monitoring. A Model 55A Shure unidirectional dynamic microphone is used for station announcements. Two RCA Model 70-C1 turntables are on order. These turntables will provide facilities for reproducing high-fidelity programs from vertical and from lateral transcriptions.

The entire speech equipment installation is particularly useful in connection with undergraduate communication engineering courses. Many principles taught in these courses are vividly demonstrated through the use of this equipment.

THE STATION LICENSE APPLICATION

As soon as the construction of the station was completed, a telegram was sent to the Secretary of the Federal Communications Commission in Washington, D. C., requesting permission to operate the station during the ten-day equipment test period. A copy of this telegram was sent to the Radio Inspector in charge of this district, Federal Communications Commission, New Post Office Building, Atlanta, Georgia.

At the termination of the equipment test period, in accordance with Section 2.42 of the FCC Rules and Regulations, an application was filed with the Commission for the Station License. Simultaneously, permission was requested by telegraph to proceed with the program test period in compliance with Section 2.43 of the FCC Rules and the special endorsements on the Construction Permit.

The complete Station License application for the Developmental Broadcast FM Station is included in the following section.

F. C. C. Form No. 310

File No. .....

Call letters W4XAG

UNITED STATES OF AMERICA

FEDERAL COMMUNICATIONS COMMISSION

APPLICATION FOR { RELAY / INTERNATIONAL / TELEVISION / FACSIMILE / HIGH FREQUENCY / EXPERIMENTAL } (Check type of station) BROADCAST STATION LICENSE

x Developmental Broadcast

(Submit in duplicate to Federal Communications Commission, Washington, D. C. Swear to one copy)

To the Federal Communications Commission:

1. Name of applicant * Georgia School of Technology

2. Post-office address: State Georgia City Atlanta

   Street and number 225 North Avenue, N. W.

3. Construction permit under which construction has been made:

   File No. B3-PRX-59 Date January 25, 1945

4. Construction of station was commenced February 15, 1945 and was completed September 1, 1945, and is now in satisfactory operating condition and ready for regular operation.

5. Description of transmitting apparatus which has been constructed pursuant to said construction permit:

   (*a*) Make Western Electric Type No. 503A-1 Serial No. 114

   (*b*) Oscillator: Type of circuit On File Number, manufacturer's name, and type of tubes 2 RCA 6J5

   Actual plate current per tube 6.6 ma Plate voltage 280

   (*c*) Last radio stage: Number, manufacturer's name, and type of tubes 2 WE 357A

   On File

   Actual plate current per tube 305 ma Plate voltage 2890

   (*d*) Modulator or last audio stage: Number, manufacturer's name, and type of tubes 2 RCA 6J7

   On File - - Frequency Modulation

   Actual plate current per tube 6.1 ma Plate voltage 280

* Name must be identical with that used in construction permit.

16—5659

(e) State name and type number of frequency monitor installed Lampkin Micrometer frequency meter Type 105 used with Hallicrafters S-36 and S-1B Receivers.

(f) How often will checks of the calibration of the monitor be repeated? Calibration will be checked daily against WWV.

(g) Attach block diagram of tube complement from microphone on. Western Electric 23-C Speech Equipment and 503A-1 transmitter. See Exhibit A

(h) Were all operating values specified above obtained and maintained on equipment tests? Yes

If not, give full details ———

6. In what respect, if any, does the apparatus constructed differ from that described in the application for construction permit or in the permit? ———

7. (a) Attach data on checks of calibration of frequency monitor, giving dates, reading of monitor and external standard at same time throughout calibration. Include explanation of all adjustments if any. (The monitor must be adjusted to within 5 parts per million of assigned frequency.) See Exhibit B.

(b) Attach sketch and dimensions of antenna system. See Exhibit C.

8. (a) Location of transmitter (all classes except portable or mobile relay):

State Georgia County Fulton City or town Atlanta

Street and number 225 North Avenue, N. W.

N. latitude: Degrees 33, minutes 46, seconds 20

W. longitude: Degrees 84, minutes 23, seconds 43

(b) If relay: Portable ——— Mobile ———

Area in which station is to be used ———

9. (a) The call letters authorized are W4XAG

(*b*) The frequencies or band, power, and hours of operation authorized are as follows:

Frequencies [1] (kc)	Hours [2]	Maximum Power [3] (watts)	Emission [4]	Modulating Frequency [5] (cycles)
49,500	unlimited	1000 watts	A0, Special	
49,700			and	
49,900			Special for	15,000 c.p.s.
99,000			FM	
99,400				
99,800				

[1] List frequencies separately.
[2] Indicate as unlimited, day only, etc.
[3] Maximum rated carrier power of transmitter.
[4] A_3, A_4, and/or special. List each type of emission separately for each frequency. Describe special emission in space for remarks below.
[5] Give maximum modulating frequency employed in normal operation opposite type of emission involved.

REMARKS: Present, initial operation is on 49.5 megacycles.

10. Applicant represents that all the terms, conditions, and obligations set forth in the above-described construction permit have been fully met, except as follows: No exceptions

11. Applicant reaffirms the truth, as of the date of this application, of all statements made in the application for construction permit pursuant to which said construction permit was granted.

12. Applicant waives any claim to the use of any particular frequency or of the ether as against the regulatory power of the United States because of the previous use of the same, whether by license or otherwise and requests a station license in accordance with this application.

Dated this 7th day of September, 19 45

Georgia School of Technology

(Must correspond with item 1) *Applicant.*

By Blake R. Van Leer

President

Official.

(Be sure all necessary information is furnished)

16—5559

STATE OF Georgia
COUNTY OF Fulton } ss:

Blake R. Van Leer, being first duly { sworn upon his oath, / affirmed according to law,

deposes and says that he is the President of the
(If applicant is not an individual, state relation of affiant to applicant)
above-named applicant, and that the facts stated in the foregoing application and all exhibits attached thereto are true of his own knowledge, except as to such statements as are therein stated on information and belief, and as to such statements he believes them to be true.

Blake R. Van Leer.
Affiant.†

Subscribed and sworn to before me this 7 day of Sept, 1945.

[SEAL]

M. I. Whitfield
Notary Public.

(Notary Public's seal must be affixed where law of jurisdiction requires, otherwise state that law does not require seal)

Notary Public, Fulton County, Georgia,
My commission expires My Commission Expires Aug 24 1947

† Must be subscribed and verified by party applicant, by one of the parties if more than one, by an officer if applicant is a corporation, or by attorney of applicant only under the provisions of Rule 105.34 which must be fully explained.

U. S. GOVERNMENT PRINTING OFFICE 16—5659

LIST OF EXHIBITS ATTACHED

EXHIBIT A - Answer to section 5 (g).
Block diagram of tube complement from microphone on.

EXHIBIT B - Answer to section 7 (a).
Data on checks of calibration of frequency monitor.

EXHIBIT C - Answer to section 7 (b).
Sketch and dimensions of antenna system.

TUBE COMPLEMENT OF FM STATION W4XAG

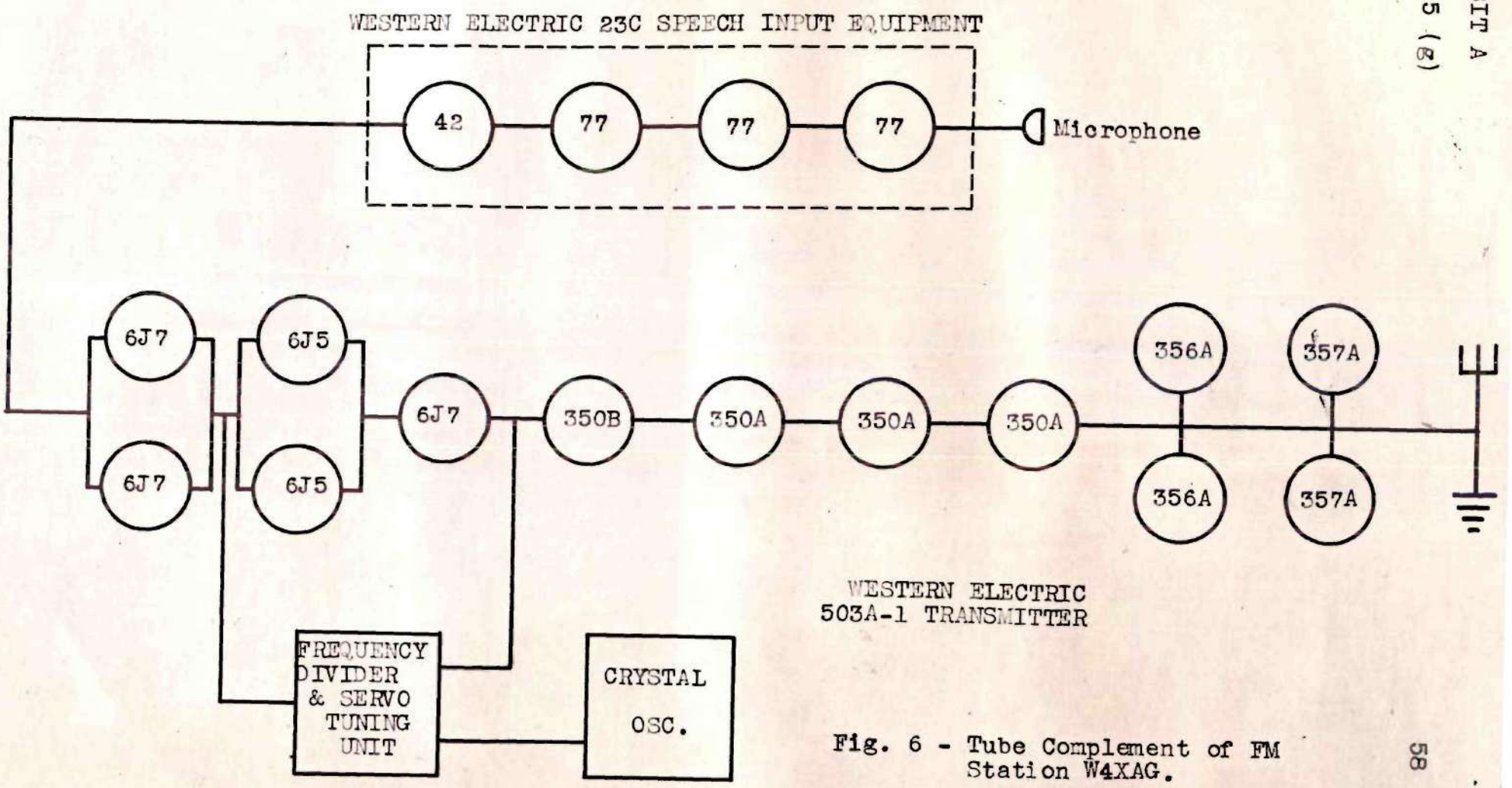

Fig. 6 - Tube Complement of FM Station W4XAG.

EXHIBIT B

7. (a) The Lampkin micrometer frequency meter type 105 was permitted to warm up for one hour before the following calibration procedure:

(1) The WWV 5-megacycle signal was tuned in on a Hallicrafters S-18 receiver. A Dumont type 208 cathode-ray oscillograph was connected to the output of the receiver to detect, visually, low-frequency beats.

(2) The frequency meter dial was set to a reading of 4448 dial divisions, which corresponds exactly to a fundamental frequency output of 2.5 megacycles. The frequency-adjusting trimmer condenser on the frequency meter was then adjusted for zero beat between the second harmonic of the frequency meter and the WWV 5 megacycle signal.

The transmitter frequency was checked as follows:

(1) The frequency meter dial was set to a reading of 3850 dial divisions, which corresponds exactly to a fundamental frequency output of 2.475 megacycles. The 20th harmonic, 49.5 megacycles, was tuned in on the Hallicrafters S-36 receiver.

(2) The 49.5 megacycles output signal from the 503A-1 transmitter was adjusted to zero beat with the 20th harmonic of the frequency meter by adjusting the frequency of the low-frequency crystal oscillator in the transmitter.

EXHIBIT C

Sec. 7 (b)

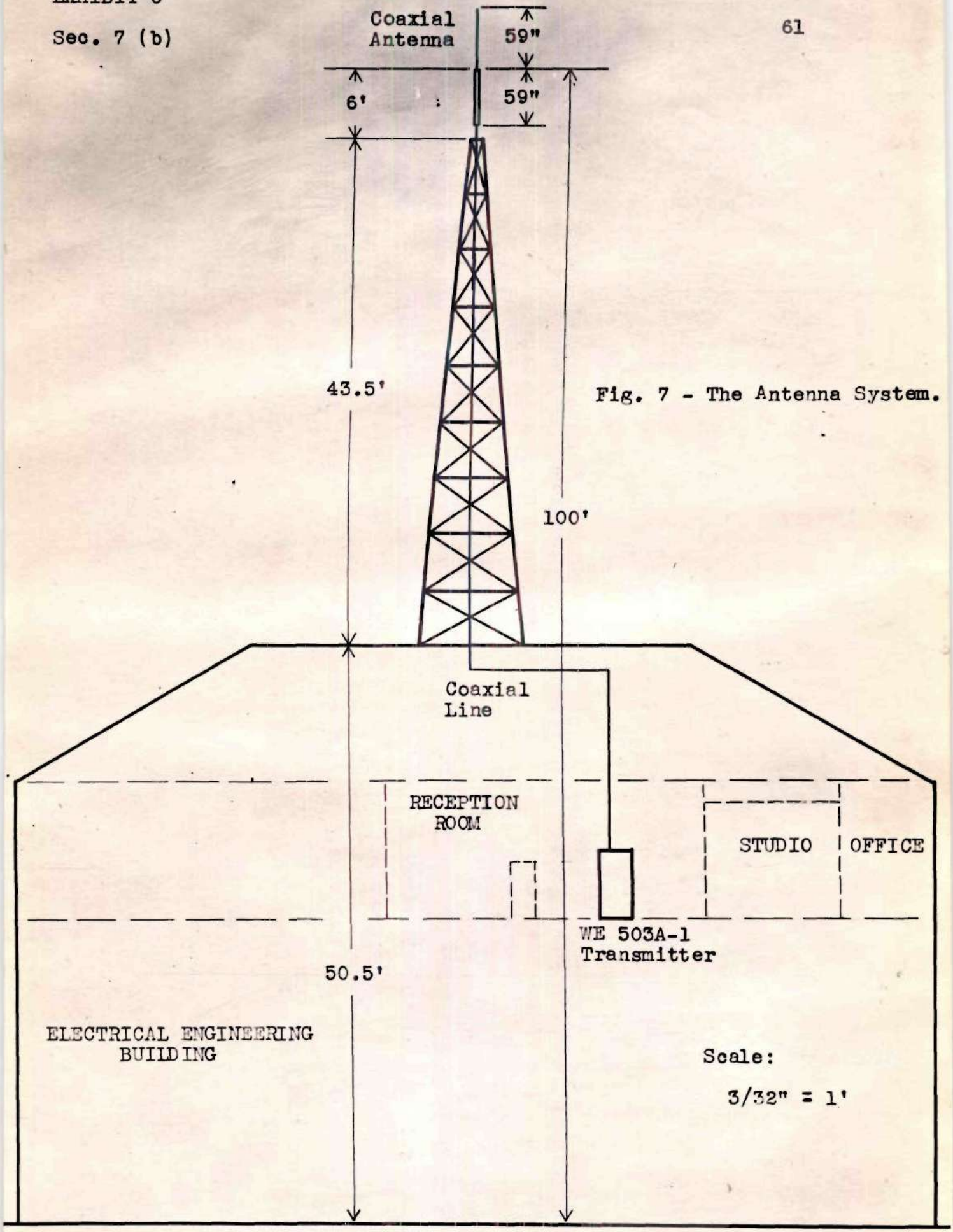

Fig. 7 - The Antenna System.

OPERATION OF THE STATION

The Rules and Regulations of the Federal Communications Commission require that the person on duty at the station be a licensed operator holding a First Class Radiotelephone Operator license. This license and the Construction Permit are posted in a conspicuous place in the transmitter room.

Daily program and transmitter logs are kept in accordance with the FCC rules. The copies of these required logs and of a daily transmitter check sheet are kept on file in the FM office.

The station is signed on and off in strict compliance with the FCC rules. Station announcements identifying the station are made every half hour.

Permission was granted by the Columbia Broadcasting System to transmit the network programs over the FM station for developmental and test purposes.

The procedure employed to check the transmitter frequency is outlined in the Station License application.

CONCLUSIONS

The purpose of this report is to provide a complete description of all phases of the FM Research Project beginning with the initial plan and ending with the completed station installation and licensing. This report plus the equipment instructions and the Rules and Regulations of the Federal Communications Commission mentioned in the report contain all of the information necessary for the correct operation of the station and for a complete understanding of the FM Project to date.

It is hoped that this report will serve as a guide to those students and other persons interested in radio consulting and radio broadcasting work. It is planned to prepare continuing reports in the future as the FM Project advances into the research field.

BIBLIOGRAPHY

Albert, A. L., Electrical Communication, John Wiley & Sons, Inc., pp. 21-37, 1940.

Morrison, J. F., "A New Broadcast-Transmitter Circuit Design for Frequency Modulation", Proc. I.R.E., vol. 28, pp. 444-449, Oct. 1940.

Taylor, J. P., "Antennas for FM Stations", Broadcast News, No. 39, pp. 6-13, August, 1944.

Terman, F. E., Radio Engineers' Handbook, McGraw-Hill Book Co., Inc., pp. 178-182, 1943.